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ABSTRACT

Many criticize the educational system, arguing that it suppresses individual creativity. This paper proposes an alternative instructional design which is intended to be used by educators in planning for creative learning and assessing it in the classroom. It is based on the notion that everyone has the potential to be creative and that any process that brings something into being is an act of creating. The purpose of this document is to provide a systematic approach to teaching and assessing learning. General topics discussed in the paper include: (1) subject matter content viewed as a system; (2) performance objectives for teaching a system; and (3) categories of objectives for using the system, along with corresponding evaluation methods. Samples of lessons and demonstrations are included within the various sections of the paper. (TW)

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ASSESSING CREATIVE USE OF LEARNING

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An underlying thesis for this paper is that an important goal of education should be to develop both independent and cooperative contributers to knowledge and culture. As currently designed, education emphasizes convergent thinking. That is, one common procedure taught by the instructor is preferred to many individual approaches of students. For example, children in the same class are required to use the same algorithm as the teacher for subtraction, (cf. Durnin and Scandura, 1973). There may be only one solution to a problem, (cf. Travers 1982) but that does not mean that there is only one approach to solving the problem. If art were taught as mathematics or other subjects frequently are, then there would be only one method of painting. That was the view of the renowned French Academy of Fine Arts during the last century, when the creative artists that we recognize today (eg., Van Gogh, Cezanne, Gauguin) worked outside the Academy.

Many criticize our educational system because it suppresses individual creativity, but few critics offer constructive or useful alternatives that a teacher may use within the constraints of the school setting. The most radical approach as proposed by A.S. Neil (1960), or Rousseau before him, appears not to fit our societal and economic structures, much less our educational system. What is proposed in this paper is an alternative instructional design, that

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educators may use for planning creative learning and assessing it in the classroom.

Although there exist many views of creativity (cf. Bloomburg, 1973), the view taken here is similar to that of the humanists (e.g., Rogers, 1954) and to that of Piaget (cf. Travers, 1982), that everyone has the potential to be creative or is creative. Any process that brings something into being, even though it is ephemeral such as a performance or a lesson, is an act of creating. Some individuals may be judged by society, colleagues or critics to be more creative or better creators than others, but it is not the intention here to become involved with qualititative judgments. The purpose is merely to provide a systematic approach to teaching and assessing creativeness of learning.

The following topics will be discussed: subject matter content viewed as a system; performance objectives for teaching a system; categories of objectives for using the system and corresponding evaluative methods.

Content as System

Content as given to the teacher and instructional designer, reflects the values of departments of education in governments, professional organizations, text book writers and publishers, and not least of all, the local school boards and administrations. Content, as the word implies, is the matter of education and there are many vested interests that protect what it should be or not be for various reasons. It is usually revered by these interest groups and is sometimes allowed to change slowly with time. Certainly to abandon it would be cataclysmic regardless of the value of any program proposed

to replace it. What is being suggested is not replacement but simply an alteration on the view of content.

The word "system" is currently a popular word in education especially in educational design. Although it may have many meanings, it frequently applies to a methodical approach for analyzing an organization or structure. The connotation to be used here is closer to a mathematical meaning of the term, a set of elements, operations or relations (cf. Scandura, 1973). The whole numbers with the operation of addition would be a system. The numbers are the elements and addition, the operation.

Examples of system exist throughout the universe. At a macro level the sun, planets, asteroids and comets with the relation of betweenes form a system.; and at the micro level, the atom is a system with relations between electrons, neutrons and protons and operations of energy change or radioactive decay.

The representations of a system, as shown by the exmaples above, need not exhaust all possible elements or relations or operations of the system. In fact, our lack of knowledge of a complete system, as is the existing case with both the solar and atomic systems, allows for creative searches for new elements, relations or operations.

Even human environments such as the classroom may be represented by a system. The teacher and students may be viewed as the elements with relations being between the teacher and the students, and between students. Also teachers and students, can and frequently do, create operations for this system, such as changing seating arrangements and interchanging teacher-student roles.

Although the simple system of whole numbers under addition was

chosen as one example of viewing content as system, the concept can be extended to less well defined areas of content. All the elements or operations may not be easily identified, but the general concept can still be applied. For example, consider the system of simple sentences. The elements are vocabulary with relations of verbs, modifiers and nouns, and the operation are rules for sentence construction. An even more elusive system would be a period from history such as revolutionary America. For elements one could consider the persons, locations, events of the era and for relations, linear time sequence, governmental and military organizations and personal or national postures. Certainly, this does not exhaust all the elements or relations, but as stated before, not all possible elements or relations need be considered; others could be discovered or added. With the system of whole numbers this could mean discovering the relation of "greater than" or with the history example finding unrecognized persons or events. Systems may also be contained in larger systems; the system of whole numbers with addition, for example, is contained within the system of integers and the revolutionary period is contained within larger systems of history. Thus, most, if not all, content in a curriculum may be viewed as systems.

Performance Objectives for Teaching a System

If a teacher has a goal to teach a system, then he will present information and intellectual skills (Gagne and Briggs, 1979) about the system. Teaching information consists of teaching the elements, relations and operations of a system, so that the student is able to recall or identify them. Teaching intellectual skills, consists of demonstrating the use of relations and operations of a system. For

example, with the whole numbers to teach the intellectual skills is to show students how to add any two whole numbers. Not all operations, though, are intellectual skills (e.g., chemical reactions).

What is taught is not necessarily what is learned. Corresponding to a teacher's goal for instruction is an expectation of student competency, which is generally expressed by a performance objective. A performance objective is a description of the physical behavior a learner exhibits after instruction or practice. Many diverse criteria are cited by various curriculum designers as necessary for a rigorous statement of a performance objective, but most agree that the essential characteristics are: 1) stating the given or initial conditions, 2) having an action verb that indicates operation or change and 3) stating the expected or appropriate result of the action. Other criteria, might be the method the student is to use, instruments available, number of correct responses or time constraints. These latter criteria, however, are viewed in this context as optional. For example, if we take from a text on English (Campbell, 1961) the system having as elements sentences and noun clauses and operations of sentence synthesis and analysis, then an information goal would be to teach the definition of the elements, noun clauses, and the corresponding performance objective would be:

To Be Given: What is a noun clause?

Student Action: To write

Result: Definition of noun clause.

If we teach the operation of synthesis as an intellectual skill then the performance objective is:

To Be Given: Two sentences

Student Action: To synthesize

Result: One sentence with a subordinate noun clause.

Corresponding to these objectives are appropriate teaching and testing strategies (see Durnin, 1984). Discussion of these strategies, though, would not be pertinent to the principle objective of this paper, to discuss assessing creative use of learning.

Categories of Goals for Using the System

In teaching the system, the instructional goals and performance objectives are convergent. That is, all students are expected to learn common accepted relations and operations. A goal of using the system, is to allow for student divergence. Each student has the opportunity to generate his or her own individual response.

Under using the system there can be many instructional goals depending on the system considered. The following are nine goal categories for using a system:

1. Problem solving
2. Problem generation
3. Internal search
4. External search
5. Proof or researched verification of statements
6. Generation of statements about a system
7. Application (real, games or imaginary)
8. Construction or discovery of a system
9. Unexpected (or unusual) productions (mathematical joke or poem)

To exemplify performance objectives associated with the goal categories, let us consider two goals for use of systems from the previously mentioned content of subordinate noun clauses, generation of statements (6) and application (7). Corresponding performance objectives would be:

1) To be given: System of subordinate noun clauses
   Student Action: To generate
   Result: Statements about the system. (E.g., a noun clause may be the object of a verb.)

2) To be given: System of subordinate noun clauses
   Student action: To write
   Result: A descriptive paragraph with sentences containing noun clauses.

According to Gagne and Briggs (1979) such performance objectives would be called cognitive strategies.

Evaluation Methods

With regard to assessing knowledge of a system, uniform responses from all students may be expected and objective or short answer tests may be used. However, if a goal is to use the system as described by open objectives then correct answer tests will not adequately assess differing individual approaches to creative uses of content. What is needed is criteria for each performance objective so that one may assess whether creative use of a system by a student is appropriate. Stating the criteria should guard against subjective evaluation of

creativeness. The criteria should test solely that the system has been properly applied.

General criteria for each category would be ideal, but at present they are lacking so particular criteria for a performance objective within a category will be demonstrated.

Problem Solving

It is postulated here that problem solving involves more than a simple application of an intellectual skill operation or relation. It involves what Scandura (1977) refers to as higher order rules that operate on operations and/or relations. Durnin (1982) lists and describes seven such processes identified by Scandura (1973). They are composition, decomposition, inverse, generalization, conjunction, restriction and selection.

These higher order rules then become the operators in a new system, where operations are the elements. For example consider the system of percent problems.

Elements	Operations
Percent, Base,	(%, Base) => Amount
Amount, Percent	(Amount, Base) => %
increase, Percent	(%, Amount) => Base
decrease, Amount of	Subtraction
increase, Amount of	Addition
decrease	

Problem solving objective

To be given: Percent problems

Student action: To generate

Result: Solution procedure

Criteria: Derived procedure solves the problem.

To assess a student's problem solving ability one checks to see if the solution procedure derived by the student solves the problem. A sample test item might be:

> George sold a house for $50,000.00 and paid a real estate agent $6000.00 for selling the house. What percent of the selling price did George have after paying the real estate agent?

Although there is only one answer, there can be many possible solution strategies. One solution procedure might be stated as:

1. Subtract 6,000 from 50,000
2. (Difference, 50,000) => %

or

1. Set up proportion $\frac{6000}{50,000} = \frac{X}{100}$
2. Solve proportion for X
3. Subtract X from 100.

The procedures are applications of composition higher order rules, since the output of one operation is the input of the succeeding operation. It is not necessary, though, that they involve operations given in the system. The only criterion to be met is that the procedure solves the probvlem.

Problem Generation

Students are always asked to solve problems but seldom asked to generate problems. The problems generated, though, should require the

use of higher order rules and not just the application of an operation of the system.

Let us consider as an example the content, incidence and refraction angles from a physics text. The system may be represented as follows:

Elements	Operations
Angles (of Incidence, <I, or Refraction, <R)	(N,<I) => <R
Substances (S)	(N, <R) => <I
Absolute indices (N) of	(<I,<R) => N
Substances (S)	S => N

Problem generation objective

To be given:	Refraction system
Student Action:	To generate
Result:	A refraction problem
Criteria:	Generation of a solution procedure to the problem requires use of higher order rules.

An appropriate student response might be the following:

Problem: If angle of incidence from air to a solid substance is 30^{o} and the angle of refraction is 19^{o}, what is the substance?

The solution requires use of inverse (i.e., $(S=>N)^{-1}$) and composition rules.

Internal Search

It is doubtful that any content, as described by system could not be expanded by unpresented elements, relations or operations. As in

the examples above, new operations may be constructed through problem solving. These operations, though, were formed from operations already given. The relation "greater than" or "lesser than" could also be added to the system and comparisons of angles and indices made. Thus, internal search to discover new elements, relations or operations may be a use of a system.

To demonstrate this category let us consider a system of intervals as taken from a calculus book.

Elements	Relations	Operations
Representations of Intervals	Bounded	Union (U)
1) Set notation (e.g. $\{X:a<X<b\}$ or $\{X:\|X-s\|<t\}$	Closed	Intersection ($\cap$)
	Open	Difference (-)
	Semiopen	Transfer from one representation to another (e.g. (a,b) => $\{X:a<X<b\}$)
2) Ordered Pairs (e.g. (a,b])		
3) Line (e.g.)		

Internal search objective

To be given:	Interval system
Student Action:	To find
Result:	New elements, relations or operations
Criteria:	Discovery was not listed in original representation and is appropriate to the system.

Appropriate student responses might include:

New element - $\{X:|X-p| >a>0\}$

New relation - inclusion ($\subset$)

New operation - computation of length of an interval

If the generation of new elements and relations is relatively easy, criteria might also be based on the number of new elements, relations or operations added to the system.

External Search

In contrast to the discovery or generation of new elements, relations or operations within a system is the search for parallels or generalization of a system. In physics, for example, the law of gravitation formed the model for Coulomb's law for charged particles. The external search should include analogies, generalizations and imbeddings.

For this category the system of mitosis from a biology text may be considered.

Elements	Relations	Operation
Cells	Stages of Mitosis	Cell Splitting

External search objectives:

To be Given:	System of mitosis
Student Actions:	To describe
Result:	A related system
Criteria:	The system is parallel, a generalization or containment of the given system,

An analagous student response might be the splitting of nomadic tribes due to population increase; a generalization might be the system of growth in a multicellular organism and an embedding could be sexual reproduction.

Verification of Statements About System

Parallel to problem solving is verification of statements about systems. In different subjects different methods are used for verification. In science students are given hypotheses or laws to reverify; in mathematics theorems to reprove and in history statements are verified through document and library research. In each, a student is given a statement about a system and is required to verify it.

To demonstrate this category for assessment let us consider pre-revolutionary America.

Elements	Relations
English Parliamentary Acts	Parliament to Crown
Crown Measures	Parliament to Colonies
Writings of English Philosophers	Crown to Colonies
Revolutionary Speeches and Documents	Between colonies
Events in England and America	Time ordering

Verification objective

To be Given:	A statement about Revolutionary America
Student Action:	To write
Result:	A paper supporting (or refuting) the statement.
Criteria:	The paper is written in an acceptable thesis format with references, correct grammar and spelling.

For example, given a statement such as "Colonial speeches, documents and actions were influenced by the writings of English philosophers", the student supports the statement by associating political speeches, documents and actions of the period with preceding views of English philosophers.

Generation of Statements

Generation of statements, hypotheses, conjectures or theses, also parallels the generation of problems. Many statements may be generated from the systems already exemplified and the statements need not be true (e.g., that the refraction indices of solids are greater than those of liquids). Verification may be required, though, to demonstrate the validity or invalidity of a statement. Thus, students according to this category are allowed to generate their own hypotheses or theses. It should follow then, as with problem solving that they should produce verification of their statement. Of course, not all statements can be verified or refuted (cf. Godel's incompleteness theorem).

As a demonstration of this category consider the following system of the Romantic Period (1800-1840) taken from a British literature text.

Elements	Relations
Sample of poets	Theme
and poems from	Narrative
the Romantic Period	Sonnet
(e.g., Wordsworth and Lucy Gray)	Ballad
	Lyric
	Ode

Statement objective

To be given:	System of Romantic Poetry
Student Action:	To generate
Result:	A statement about Romantic Poetry
Criteria:	The statement is about elements or relations of the Romantic Period

Responses might include "Wordsworth preferred the use of the Italian form of the sonnet" or "The romantic poets espoused a theme of humanism." If assessment is for breadth, criteria might include generation of as many possible plausible statements about the system. If it is for thoughtfulness in selection of statements, then the criteria might also include verification.

Application

Many systems are suited to immediate application (e.g., the percent system or refraction system). However, application need not imply practicality. There may be more worth or imagination in asking, "To what may romantic poetry may be applied?" Possible responses could be to convey secret messages or for constructing crossword puzzles.

For this category a beginning lesson from a text on learning English as a second language will be used.

Elements	Relations
Formalized greeting and questions	I'm (name)
Names	It's a (noun)
Vocabulary	Please, (imperative) the
Idioms	(noun)

Application objective

To be given: System of greetings and commands

Student Action: To write

Result: A conversation

Criteria: Proper sentences, introduction and closure.

A sample response conversation might be:

Sarah: Good morning, Alfred

Alfred: Good morning, Sarah. How are you?

Sarah: Fine, thanks.

(Enter Brent)

Brent: Hello. My name is Brent. What are your names?

Alfred: I'm Alfred.

Sarah: I'm Sarah.

Brent: What is that?

Alfred: It's a door.

Brent: Please, open the door.

Alfred: O.K.

Brent: Thank you. Goodbye.

Alfred: Goodbye.

Sarah: So long.

Construction or Discovery of a System

The above categories of creative activity assume at least some knowledge of a system, but another important activity is to give the students a set of elements and to let them discover or generate a system. In both the arts and sciences new systems are constantly being developed or discovered.

For this category we will consider first the performance objective and then the systems as possible responses.

Discovery objective

To be given: 1 rubber rod, 1 glass rod, 2 hanging pith balls, silk cloth and cat skin

Student Action: To generate

Result: A system

Criteria: Contains at least two of the three:element, relation, or operation.

A resulting representation might be:

Elements	Relations	Operations
Charges	Repulsion	(catskin, glass rod)=>
Glass rod	Attraction	charged glass rod
Rubber rod	Neutral	(silk cloth, rubber rod)=>
Pith balls		charged rubber rod
Silk Cloth		Transfer of Charges
Cat skin		Neutralization

Another representation might be:

Elements	Relations	Operations
Glass induced charge	Attraction	Transfer of charge
	Repulsion	Neutralization of charge
Rubber induced charge	Neutral	

There can be many representations depending upon what students discover or how they view the system. Although some representations of the system may be more convenient or more elegant than others, the criteria should be consistently applied to all.

Unexpected or Unusual Uses

Although this may not be a category to be assessed, I believe it is important that students should think of unusual relations between systems, for example, a poem or joke about intervals, relating romantic poetry to physics, or writing romantic poetry for science fiction (e.g., Geiger geiger burning bright) or some imaginary place and time. Other outcomes may be from violations of standard operations or relations of a system (e.g., Joyce's stream of consciousness). The importance of assessment may be less with this category than with the others; yet it should be one in which students are allowed to explore.

The goal categories stated above are not meant to be exhaustive nor are they necessarily mutually exclusive. They represent merely frames of reference for using a system and developing cognitive strategy performance objectives which may be assessed. Not all systems may have goals in each category, but there should be at least one category to which a system can be applied and performance measured.

The underlying rationale of the system and category model is to provide a basis for introducing more creative activities into classroom teaching and to assess the creative achievement of students with regard to what they have learned.

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